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# Feeding behavior of lessepsian fish *Etrumeus teres* (Dekay, 1842) from the Mediterranean Waters, Egypt

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**Abstract** The present work studies the food and feeding habits of lessepsian fish, *Etrumeus teres* (Dekay, 1842) to know its feeding behavior in relation to sex, length and season as well as its preference for food items. Fish samples were collected monthly from Alexandria landing centers during 2008 and a total of 490 individuals were selected to be examined for this study. The results indicated that round herring *E. teres* feeds on a variety of food materials mainly small crustaceans (shrimp larvae, isopods and amphipods) followed by fish larvae (Engraulidae, Mugilidae and Labridae); Mollusk (few gastropods and cephalopods) as well as food remains. The feeding intensity showed the highest values during winter and spring (82% and 50.55%, respectively) while the lowest values were during summer and autumn (40.14% and 38.1%, respectively). Round herring *E. teres* shifted their fullness index as they grow in length where the lowest value of this index was recorded for a length group of 9–15 cm TL and the highest value was recorded for a length group of 15–20 cm TL. According to the modified food index (MFI), crustaceans were the first preferable food item represented mainly by shrimp larvae (61.69%) followed by fish larvae which were represented mainly by Engraulids (23.58%). Diversity index (H′) of food items for males was higher than females; while this index (H′) for the small length group (9–15 cm) was higher than the other length groups which suggest that fishes of smaller length seemed to be more active in capturing different food items. Also, the value of diversity index (H′) of Autumn was higher than other seasons. The overlap test (T) showed no obvious differences between males and females and between different length groups where the value was found to be "1" indicating that all fishes have the same mode of feeding. Food items were attracted and aggregated by artificial light of purse-seine using light giving a positive

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effect of this fishing method for pelagic fishes particularly *E. teres* to feed on those materials. From the previous findings, it can be speculated that, round herring *E. teres* from the Egyptian Mediterranean Waters is zooplanktivorous.



## Introduction

Round herring, *Etrumeus teres* (Dekay, 1842) is a member of Clupeid species and it is a pelagic Indo-Pacific species which is mainly caught by purse-seine using light. It is also of high economic value and is widely distributed in many countries of the world (Farrag, 2010). It migrated from Red Sea to Mediterranean water via Suez Canal and showed rapid distribution in different Mediterranean countries, it was first recorded in Haifa Bay, 1961 (Whitehead, 1963); Mediterranean, Egypt (El-Sayed, 1994); Iskenderun, Turkey during 1994–1996 (Basusta et al., 1997); Antalya, Turkey, 1997 (Yılmaz and Hossucu, 2003); Cyprus, 1999 (Golani, 2000); Rhodes, 2003 (Corsini et al., 2005); Cyclades, 2004 (Kallianiotis and Lekkas, 2005); Chania Bay, Crete, 2004 (Kasapidis et al., 2007); Lampedusa (Falautano et al., 2006); Hydra Island (central Aegean), 2005 (Zenetos et al., 2007) and Dikili coast, Aegean Sea, Turkey, 2009 (Yarmaz et al., 2010). This species constituted about 25% of the landed purse-seine catch in the Egyptian Red Sea (Mehanna and El-Gammal, 2005). In the Egyptian Mediterranean Water and after its migration, it became settled in and seems to be well established constituting about 16% of the landed catch of purse-seine using light during Summer, Spring and Autumn (Akel, 2009). By the year 2010, this species showed 10.93% per boat/night (CPUE)) of the average for the annual landed catch per unit effort of purse-seine using light in the Egyptian Mediterranean Waters in Alexandria (Farrag, 2010). The rapid expansion of this fish and other lessepsian species in different Mediterranean countries attracted the scientists to study and manage these populations. The biological data are important steps in the field of fisheries management. However, very few studies concerning some biological items in the Mediterranean Sea have been done. No information about biological features particularly feeding habits of this lessepsian species in the Egyptian Mediterranean Waters. So, studying the feeding habits of fish is useful to understand the functional role of the fish within their ecosystems since they indicate relationships based on feeding resources and indirectly indicate community energy flux, which allows inferring competition and predation effects on community structure (Cruz-Escalona et al., 2000; Hajisamae et al., 2003). Furthermore, it is a subject of continuous research because it constitutes the basis for the development of a successful fisheries management program on fish capture (Oronsaye and Nakpodia, 2005). The present work aims to study the feeding habits of the lessepsian fish *Etrumeus teres* (Dekay, 1842) in the Egyptian Mediterranean Waters with variations based on sex, length and season.

## Materials and methods

### *Study area and sampling sites*

The area of investigation is located between 31 00 and 31 35 N and 29 18 00 and 30 30 00 E extended from El-Hammam to Rashid on the Egyptian Mediterranean coast (Fig. 1). Random samples of round herring *E. teres* were collected monthly from the catch of purse-seine using light from Alexandria landing centers during the period from January to December 2008. A total of 490 fresh fish samples were collected and transformed directly from landed site to the Fishery biology lab of National Institute of Oceanography and Fisheries (NIOF), Alexandria which is located near the landed center. Specimens were measured (9–25 cm Total Length, 6–137 gm Total Weight), sorted according to sex and length; they were divided into three length groups (9–15 cm, 16–20 cm and 21–25 cm). The body cavity was opened to allow quick preservation and all specimens were preserved in 10% formalin solution for later examination. After being dissected, each of the fish's stomach contents were removed and washed with water. The food contents of each stomach were preserved in 70% ethyl alcohol for later microscopic examination. Food items were identified to the available lowest taxonomic taxa.

Feeding intensity was based on the percentages of Vacuity index (VI) (Empty stomachs) and fullness index (The percentage of stomachs containing foods) in relation to the total number of examined stomachs (AbdEl-Aziz and Gharib, 2007).

### *Feeding activity*

The feeding activity of round herring, *E. teres* was studied using the following indices

#### *Occurrence index (OI)*

The percentage of stomachs having a specific food item to the total food items found in the examined stomachs (Rizkalla and Philips, 2008).

#### *Weight index (WI)*

The percentage of the weight of a specific food item to the total weight of stomachs containing food (Rizkalla and Philips, 2008).

#### *Numerical index (NI)*

The numerical percentage of a specific food item to the total number of food items in stomachs containing food (Rizkalla and Philips, 2008).

#### *Modified food index (MFI)*

The following formula of modified food index (MFI) was used (Rodrigues, 1997):

$$\mathrm{MFI} = \sqrt{W\%}\,\frac{(O\% + N\%)}{2}$$

where $O\%$, occurrence percentage; $N\%$, numerical percentage; $W\%$, weight percentage.*Note*: The sum of the total different values of (MFI) for different food items does not equal "1"

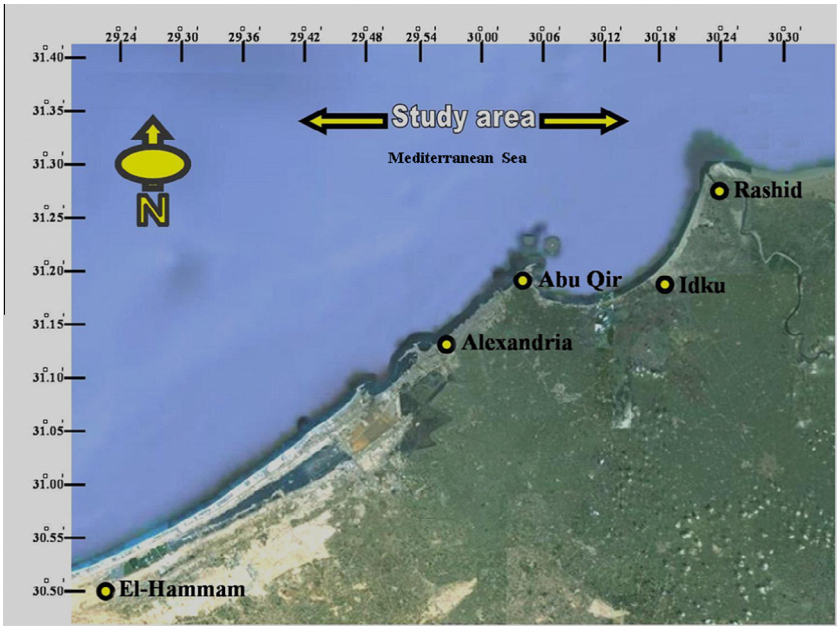


**Figure 1** The study area on the Egyptian Mediterranean coast off Alexandria.

or 100% but each value can be taken as a separate indicator for preferable food items.

*Diversity index (H′)*

The diversity of each food item according to sex, length groups and seasons was estimated by applying the following formula given by Shannon and Weaver (1963):

$$H' = -\sum_{i}^{s}(\mathrm{ni}/N)\ln(\mathrm{ni}/N)$$

where $H$, diversity of food item; ni, number of each food item to total number of all food items; $N$, total number of all food items; $S$, number of different food items.

*Overlapping index (T)*

The test of food items' overlapping was used to predict the amount of overlap between food items for different sexes, different length groups and different seasons. Overlap was estimated by using the following equation (Schoener, 1970)

$$T = 1 - 0.5\sum_{i}^{n} = 11|P_{\mathrm{Xi}} - P_{\mathrm{Yi}}|$$

where $T$, the index of overlap; $P_{\mathrm{Xi}}$ and $P_{\mathrm{Yi}}$, are the numbers of food item ($i$) for the two groups fish $X$ and fish $Y$, respectively. When the index of overlap ($T$) is 0.0 this means that there is no overlap between $X$ and $Y$. Values higher than 0.6 are considered as significant overlapping (Macpherson, 1979). Values equal to 1.0 means that the same food resources are consumed.

## Results

*Feeding intensity*

The feeding intensity of *E. teres* according to season and fish length is shown in Fig. 2a and b. Out of 490 stomachs examined, 250 stomachs were empty (51.02% of the total stomachs). The percentage of vacuity index varied with season and fish length. The highest values of vacuity index (VI) were

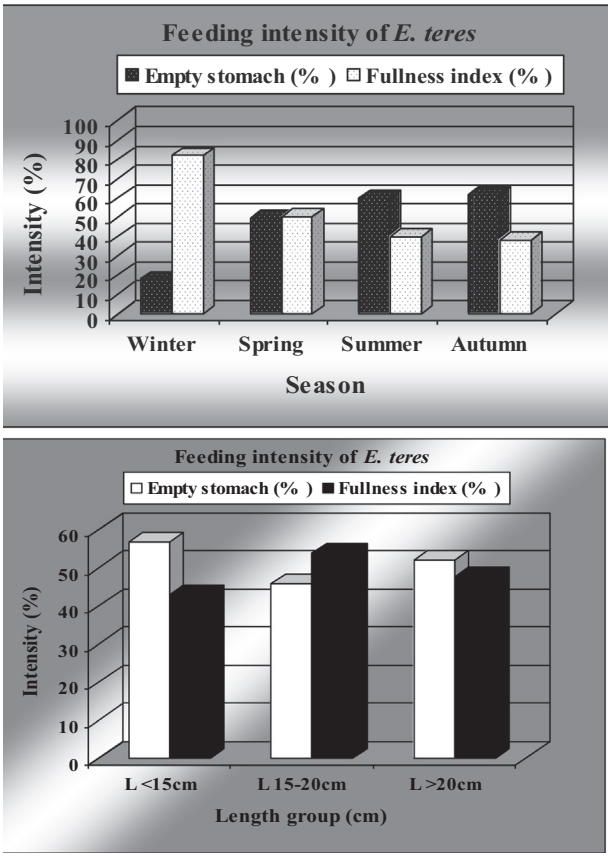


**Figure 2** (a and b) Feeding intensity of *E. teres* collected from the Egyptian Mediterranean Water, off Alexandria.

recorded during Autumn and Summer (61.9% and 59.86, respectively) and the lowest values were detected during Spring and Winter (49.45% and 18%, respectively). The length group of 9–15 cm TL had the highest vacuity VI (56.98%) and the length group of 16–20 cm TL had the lowest one (46.02%). The fullness index which is a real indicator for feeding intensity exhibited the highest values during Winter and Spring (82% and 50.55%, respectively) while the lowest values were during Summer and Autumn (40.14% and 38.1%, respectively). The highest fullness index was recorded in the length group 16–20 cm TL (53.98%) and the lowest one was recorded in the length group 9–15 cm TL (43.02%).

### *Food materials*

#### *General food items*

Out of 490 examined stomachs, 240 stomachs were found to contain food items. The general food items that are eaten by *E. teres* are shown in Table 2 and Fig. 3. There were 8 prey taxa belonging to three general categories (Fish larvae, small crustaceans and mollusks). Digested food was also recorded. As presented in Table 1, crustaceans are the most important food items in the diet of round herring which is followed by fish larvae. By number, weight and occurrence, crustaceans constituted 93.42%, 51.07% and 76.25% of the total food items, respectively. Crustaceans were represented by shrimp larvae, isopods and amphipods. Shrimp larvae were the main crustacean food items followed by isopods then amphipods which was the lowest crustaceans' food items. Fish larvae were the second class in the total food items as expressed by number, weight and occurrence as 6.51%, 30.56% and 55.42%, respectively. This category included larvae belonging to Engraulidae, Mugilidae and Labridae. Engraulidae are the most dominant fish larvae items followed by Labridae then Mugilid larvae. The third category was mollusks which illustrated the lowest appearance in food items constituting 0.08%, 0.04% and 1.67% for number, weight and occurrence respectively. The other category of the total food items is the food remains within the stomach content. This category constituted 18.24% and 49.17% for weight and occurrence respectively; it was simply the remains of unidentified organisms. According to the modified food index (MFI), Crustaceans were the preferable food item which formed about 65.82 followed by fish larvae (30.80) then food remains contributed 21.17 and the lowest value was recorded for mollusks (0.19) (Table 1).

**Table 1** General food items eaten by *E. teres* collected from the Egyptian Mediterranean Water, off Alexandria.

| Food items | N% | W% | O% | MFI |
|---|---|---|---|---|
| **Fish larvae** | 6.51 | 30.65 | 55.42 | 30.80 |
| Engraulidae | 3.67 | 25.21 | 40.42 | 23.58 |
| Mugilidae | 0.66 | 1.34 | 6.67 | 2.21 |
| Labridae | 2.18 | 4.10 | 2.92 | 3.23 |
| **Crustaceans** | 93.42 | 51.07 | 76.25 | 65.82 |
| Shrimp larvae | 86.84 | 49.71 | 66.25 | 61.69 |
| Isopods | 6.11 | 1.33 | 40.00 | 5.53 |
| Amphipods | 0.47 | 0.04 | 3.75 | 0.27 |
| **Molluska** | 0.08 | 0.04 | 1.67 | 0.19 |
| Gastropods | 0.07 | 0.03 | 1.25 | 0.13 |
| Cephalopods | 0.01 | 0.02 | 0.42 | 0.06 |
| **Food remains** | 0.00 | 18.24 | 49.17 | 21.17 |
| Total. No. items | 10653 | | | |
| Total. W. items | 505.57 (g) | | | |
| Total. No. of stomachs | 240 | | | |

N% is a numerical index; W% is the weight index; O% is the occurrence index and MFI is the modified food index.

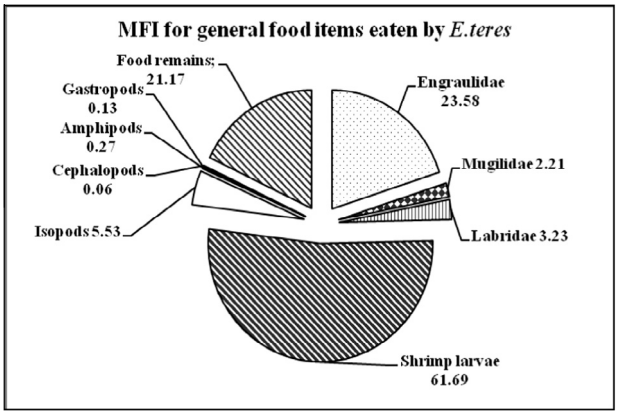


**Figure 3** Modified food index (MFI) for general food items eaten by *E. teres* from the Egyptian Mediterranean water, off Alexandria.

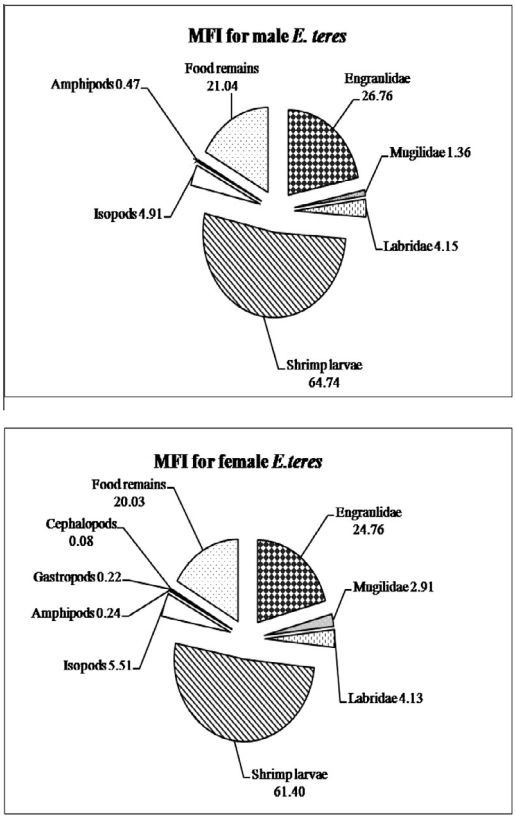


**Figure 4** Variations in food items for Male and Female of *E. teres* from the Egyptian Mediterranean Water, off Alexandria.

*Feeding variations according to sex*

Variations in feeding habits for males and females are shown in Fig. 4. In the males, Crustaceans were the most important category of food items. This category included shrimp larvae which represented the most important food items followed by Isopods and then Amphipods. The second category was fish larvae; it included Engraulidae, Mugilidae and Labridae. Engraulidae were the main food items among fish larvae followed by Labridae and then Mugilidae. The third category was food remains which occupied 46.30% of the total food items. No mollusks were observed among the food items in the examined stomachs of males.

In the females, crustaceans were also the most important category. This category included shrimp larvae which represented the first and most important food item followed by Isopods and finally Amphipods. The second category was fish larvae; it was represented by Engraulidae followed by Mugilidae and Labridae. The third category was food remains. Unlike the males, mollusks recorded in the stomachs of females of *E. teres* were of small size and number. They were represented by Gastropods and Cephalopods, and formed 0.22% and 0.08% for modified food index respectively. The test of food items' overlap "*T*" according to sex was "1". This means that males and females have the same resources of food items supported by artificial light. The test of diversity index (H′) exhibited a high value for males (0.985) while it was 0.694 for females.

*Variations in feeding habits according to fish length*

As previously mentioned the collected specimens of *E. teres* were divided into three length groups: 9–15 cm, 16–20 cm, and 21–25 cm total length. As presented in Fig. 5, it shows that in all length groups the crustaceans represented the main food item. The diet of fishes, for all length groups, constituted of shrimp larvae followed by isopods and finally amphipods. Amphipods were only found in fish up to 21 cm TL; they disappeared in the largest length groups (21–25 cm). Fish larvae came next in importance; Engraulidae fish larvae constituted the main food item in the examined stomachs while Mugilidea represented the second item of fish larvae. They were recorded only in the stomachs of fish length less than 21 cm and disappeared in length groups from 21 to 25 cm. Mollusks were less important for round herring and they were recorded only in the stomachs of fishes larger than 16 cm and completely disappeared in the stomachs less than 16 cm.

Regarding the feeding diversity (H′), the maximum value (1.165) was recorded for small length groups (less than 15 cm), followed by groups 15–20 cm which constituted 0.772. The lowest value was 0.569 for larger length groups (larger than 20 cm). The test of food items' overlap (*T*) showed no difference between different length groups. No remarkable overlapping between all length groups was recorded where they have the same value "1" for all length groups.

*Seasonal feeding variations*

Seasonal variations of the different food items, modified food index and diversity index of food items are shown in Fig. 6. Crustaceans had high values of modified food index (MFI) during Winter and Autumn forming 76.81% and 71.38%, respectively, and low values during spring and summer forming 44.76% and 22.24%, respectively. Shrimp larvae were the

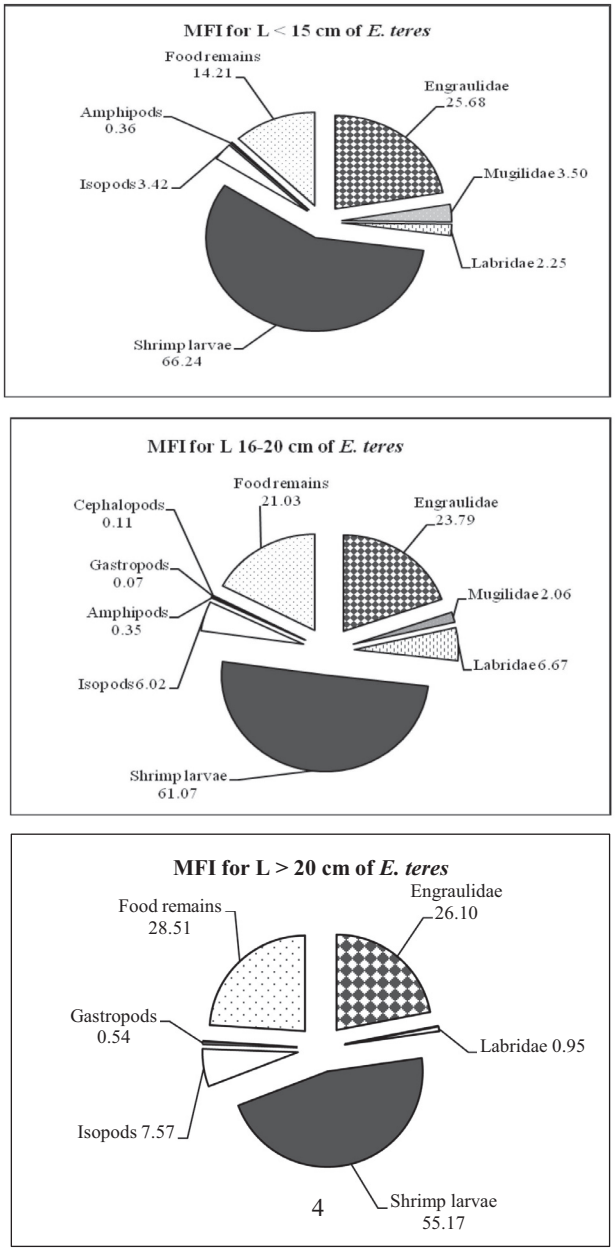


**Figure 5** Variation in food items at different length groups of *E. teres* from the Egyptian Mediterranean Water, off Alexandria.

preferable crustaceans' food items during all seasons followed by Isopods. The amphipods were completely absent during spring. The fish larvae showed high modified food indices during Summer and Autumn which recorded 54.24% and 37.92%, respectively, and low ones during Winter and Spring which recorded 24.71% and 27.36%, respectively. Engraulidae were recorded during all seasons; Mugilidae were recorded only during Winter and Spring however they were absent during Summer and Autumn. Labridae were recorded in all seasons except winter. Food remains were found during all seasons forming high values during spring and summer and low values during Winter and Autumn. Mollusks were absent during winter. The test of diversity index (H) showed that, the highest value of diversity index (2.46) was recorded during autumn and

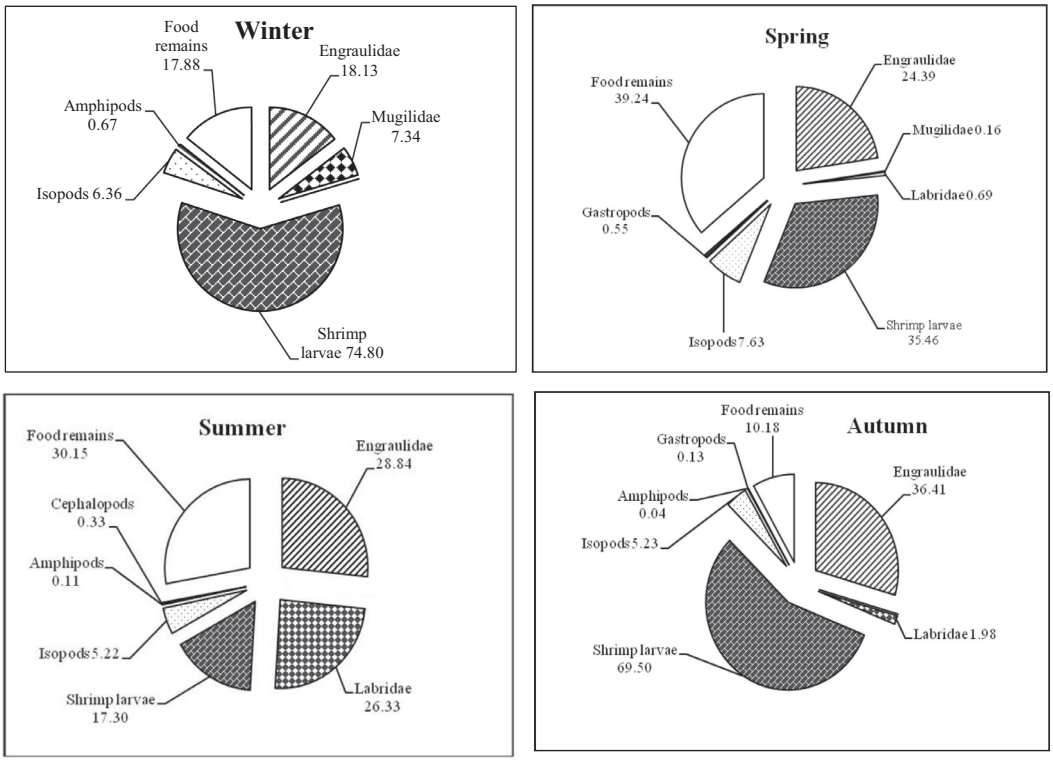


**Figure 6** Seasonal variations in modified food index (MFI) for food items of *E. teres* collected from the Egyptian Mediterranean Water, off Alexandria.

the lowest value (0.45) was detected during winter. The test of food items' overlap (*T*) among different seasons was as follows: 1.02 for winter and spring; 1.01 for winter and summer; 0.51 for winter and autumn; 0.99 for Spring and Summer; 0.49 for Spring and Autumn and 0.50 for Summer and Autumn.

## Discussion

The present results are concerned with the study of feeding intensity (fullness index and vacuity index) of stomachs and food items are eaten by round herring *E. teres* in the Egyptian Mediterranean Waters. It appears that the highest percentage of fullness index was recorded during winter (82.02%) followed by spring (50.55%). According to (Sakamoto et al., 1982), the vacuity index (VI) or empty stomachs' ratio, is an inverse indication of feeding intensity which vary according to variations in the abundance of fish, spawning time and seasonal changes in water temperature and food item. Also, during spawning time fish need more energy input in order to meet the reproduction requirements (Froese and Pauly, 2000). This finding agrees with the present results where the highest percentage of fullness index was recorded during spawning season which may be due to the need of energy for spawning as mentioned by Farrag (2010). The lowest value of fullness index (43.02%) in the present work was recorded for the length group 9–15 cm and the highest value (53.98%) was recorded for the length group15–20 cm. Also, this result may be attributed to the high abundance of the group 15–20 cm.

Regarding, the general food items, these materials were small crustaceans, fish larvae and mollusks. Larrenta (1960) emphasized that most sardine species (Family: Clupeidae) are filter feeders that feed on both phyto and zooplankton. Hashem et al., 1982 stated that the feeding habits of different species and also within the same species can be varied due to the differences in the fishing method where, they concluded that sardine caught by purse-seine feeds particularly on zooplankton while the sardine that was caught by gill net and beach seine is a filter feeder, feeding mainly on phytoplankton and may extend to zooplankton. Furthermore, there are two categories of purse-seine nets (Daytime and night purse-seine using artificial light). Since, this light of purse-seine attracts fishes; it must be taken in consideration of the study (Rizkalla and Faltas, 1997). Due to the few literatures on round herring *E. teres* as it is a pelagic immigrant species caught mainly by purse-seine using light (Mehanna and El-Gammal, 2005 and Farrag, 2010), the present results were compared with those given by other authors on different pelagic species caught by different fishing nets focusing on the purse-seine using light in/out Egypt. The result of the present study is in accordance with that of Allam, 1979 on *Trachurus mediterraneus*, Hashem et al., 1982 on *Sardinella aurita* and *Sardinella maderensis*, Hassan, 1990 on *Boops boops* and Allam, 1996 on *Trachinotus ovatus* and Rizkalla and Faltas (1997) on *Scomber japonicus*. These species are pelagic species caught by purse-seine, and all of them feed mainly on fishes (fry and larvae), Decapods, Shrimps, Amphipods, Isopods and Mollusk.

Concerning the studies that were made outside of Egypt on the same genus of *E. teres* and other species under the same genus, the present results showed a slight agreement with those of Bianchi et al. (1993) on *Etrumeus whitehead* from Namibia waters which feeds on zooplankton particularly Copepods;

Chen et al. (1992) reported that *E. teres* from the northern Gulf of Mexico United States feeds mainly on Euphausiids, fish larvae, Copepods and Gastropods; Tanaka et al., 2006 who stated that the diets of *E. teres* from the northern and western coasts of Kyushu, in the north–eastern part of the East China Sea was dominated by calanoid copepods. Such differences in food materials may be attributed to the regional differences of food materials in different habitats, but there is an agreement in the mode of zooplanktonic feeders.

Modified food index (MFI) is used as an indicator for the preference of food items. In the present study, Crustaceans were the first preferable food item followed by fish larvae. The presence of small Crustaceans, fish larvae and few mollusks indicated that *E. teres* has the ability to feed throughout the water column from the bottom to the surface layer where the flourishing of large zooplankton particularly fish larvae that is attracted and concentrated by artificial light during fishing time. From another point, the presence of shrimp larvae as preferable food items may indicate that this species has nocturnal activity reflecting the agreement with Lindsay (2006) who stated that round herring stays as a dense shoal on the Sea bed during day time and rises into the upper water column to feed during the night; Mehanna and El-Gammal (2005) and Farrag (2010) stated that this fish is caught mainly by the net of purse-seine using light.

Feeding activity and feeding intensity depend (in most cases) on the sex and length of fish (Owolabi, 2007). According to the present results, the feeding habits of *E. teres* showed no significant difference between males and females and both sexes have the same diet composition with nearly the same concentration and distribution except for the mollusks which were recorded only in the stomachs of female. The feeding diversity (H′) was 0.99 for male and 0.69 for female. This may be due to the higher feeding activity of males as compared to females. This finding is in accordance with that of Rizkalla and Philips, 2008. The overlap index value "*T*" is sensitive to the taxonomic level at which food items are identified, it is usually applied to compare the food resources between two species or sexes. The overlap index between males and females of *E. teres* was "1". This means that both sexes of *E. teres* have the same resource of food items as mentioned by Rizkalla and Faltas (1997).

According to the variation in length, the selected fish shifted their diet composition as they grow, which may be an adaptation to reduce intra-specific competition among different size groups (Guruge, 2002). In the present study, the maximum value of feeding diversity (H′) was detected for the small length groups (less than 15 cm) while the least value was recorded for the larger length group (more than 20 cm) suggesting that fish of smaller length seems to be more active in capturing different food items compared to the medium and larger length fish. This length difference in the degree of exploitation of food resources is of immense advantage in the reduction of intra-specific competition in the population. The value of overlap index "*T*" between different fish length groups was found to be "1". This means that all the selected length groups have the same resource of food items.

Fishes have a capability to adjust its diet according to the seasonal abundance of the food item (Nieland, 1982). In the present work, *E. teres* preferred small crustaceans during all seasons except summer season in which fish larvae were the preferable food items. This may be attributed to the more flourishing and diversity of fish larvae during summer in the Egyptian Mediterranean Waters as well as the effect of the artificial light of purse-seine to flourish phytoplankton that make an attraction for fish larvae and other zooplankton. The maximum value (2.46) of diversity index (H′) was recorded during Autumn and the lowest value (0.45) was detected during Winter. This difference may be due to the wide diversity of food items in the Autumn season. The test of overlap index "T" between seasons in the present work was 1.02 for Winter and Spring; 1.01 for Winter and Summer; 0.99 for Spring and Summer. These values pointed out the absence of an obvious difference between the three seasons and showing they have the same kind of food items. The value of overlap index "*T*" was 0.51; 0.50 and 0.49 for Winter and Autumn; Spring and Autumn and for Summer and Autumn, respectively. This difference between the latter three seasons may be attributed to the remarkable difference in the value of diversity index between autumn and other seasons.

In conclusion, the present study presents high values of the fullness index during Winter and Spring in accordance with Farrag (2010) who stated that winter and spring are the spawning season during which this fish needs the most of energy. It is considered a nocturnal species as supported by Lindsay (2006) who stated that since the round herring stays as a dense shoal on Sea bed during day time and rises into the upper water column to feed during the night and Farrag (2010) who stated that this species caught mainly by purse-seine using light which operates fishing activities during the night. Furthermore, Food items eaten by *E. teres* reflected a varieties of food items thought water column starting from small benthic mollusk to more abundance of small crustaceans mainly shrimp larvae in water column as well as fish larvae in the upper water layer. The light of purse-seine plays an important role to attract, aggregate and concentrate food items which the pelagic fishes, particularly round herring *E. teres* aggregate to feed on, and this confirms that this species of fish can be considered a Zooplanktivorous.

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